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DEVICE FOR INCREMENTAL MEASUREMENT OF POSITION

The present invention relates to a device for the incremental measurement of the displacement and position of two objects relatively movable in translation.

Devices of this type are known, for example, from patent applications WO 89/02570 and WO 91/04459. These devices comprise a scale connected to one of two objects, said scale consisting of a metal ribbon comprising a graduation formed by a longitudinal succession of openings with pitch p and width p/2, as well as an electromagnetic detector connected to the other of said objects and which explores the graduation of the scale, thus providing a measurement signal representative of displacement.

According to application WO 89/02570, the detector, which can, for example, be magnetic, magnetoresistive, inductive, or capacitive, can comprise a single element placed on one side of the perforated ribbon.

According to application WO 91/04459, detection occurs through the use of a permanent magnet that generates a magnetic field and a magnetic field detector element arranged on the same side as the scale. However, an inductive detector based on eddy current losses can also be used between the openings in the scale. In all cases it is the variation in induction that produces the measurement signal, which operates within the two following limits of resolution or definition.

In industrial use play in the scale guide system is needed to provide room for the passage of chips, which are often carried along by the scale, as well as to allow the free movement of the scale at high speed.

The results in play in the scale, which moves away from and back to the detector, causing the shape and amplitude of the detected signal to vary. Also, according to the laws of magnetic induction, variations in the speed of travel of the scale result in variations in the amplitude and shape of the signals, unsuitable for processing and which prevent any form of operation other than go/no-go. This limits the resolution obtained between the openings, which cannot be easily reduced by simple methods.

To overcome these various drawbacks, the invention describes the realization of a device for measuring displacement and position, using a perforated metal ribbon, which, unlike the previous devices shown by the prior art, implements a measurement signal that is less sensitive to movements of the scale and variations in its speed. The invention is designed to obtain a stable signal that is easy to implement and which offers greater resolution or definition than that provided by the prior art.

To this end the invention concerns a device for the incremental measurement of displacement and position of two objects relatively movable in translation, comprising a scale connected to one of the two objects and consisting of a metal ribbon comprising a graduation formed by a longitudinal series of openings with pitch p and which present, lengthwise along the scale, a dimension p/2, a detector connected to the other of said objects, which explores the

graduations on the scale, said detector comprising two parts situated on opposite sides of the scale, and a circuit for operation of the detector measurement signal, characterized in that the detector comprises a transmitter arranged on one side of the scale, comprising at least one coil powered by a monovoltage high-frequency pulsed electrical signal and designed to produce a high-frequency electromagnetic field concentrated on the scale, and a receiver, arranged on the opposite side of the scale, facing the transmitter coil and designed to produce, by induction, a high-frequency chopped electrical signal, which is amplitude-modulated by the scale during displacement between a high amplitude, which occurs when the scale is located between the transmitter coil and the receiver, and a low amplitude, which occurs when an interval between two successive openings on the scale falls between the transmitter coil and the receiver.

By monovoltage high-frequency pulsed electrical signal we are referring to a signal above a frequency on the order of 1 MHz. Unlike lower frequencies, such as those on the order of tens of kHz, these high frequencies can be used to prevent deviations in signal amplitude and shape associated with thermal variations and the square of the speed of travel of the scale.

A transmitter is arranged on one side of the scale and comprises at least one coil powered by a monovoltage pulsed electrical signal to produce a high-frequency electromagnetic field.

A receiver or antenna is arranged on the side opposite the scale, facing the transmitter and turned to receive the transmission of the high-frequency signal.

Hereafter, this antenna is represented in the nonlimiting form of a coil. To simplify the representation any other HF field-effect receiver can also be used.

Through the Faraday screen effect the displacement of the scale modulates the high-frequency signal transmitted between a high amplitude-which occurs whenever the signal sent from the transmitter to the receiver passes through an opening in the scale - and a low amplitude - which occurs whenever a metal interval between two openings cuts this transmission. Since the coils and the air gap are fixed, the transmission can only vary in the presence of the scale which behaves like a screen connected to a ground. And because play in the scale has very little effect, the signal obtained is very stable.

Moreover, signal stability is enhanced as detection becomes less dependent on the nature of the metal, the conductivity of the scale or its magnetism, or its speed of travel. In this way, a high-amplitude measurement signal is obtained which is easy to implement using an HF transmission above a frequency on the order of 1 MHz. A detector can preferably consist of two transmitter/receiver groups where the two groups are offset lengthwise along the scale and separated by n x p + p/2, where n is an integer. In this way a metal interval between two openings falls between a transmitter and a receiver whenever an opening falls between the other transmitter and receiver.

Within the context of the invention, each coil can comprise a winding arranged within a ferrite pot core whose dimension, along the length of the scale, appreciably corresponds to the dimension p/2 of the openings along the length of the scale.

According to a preferred embodiment of the invention, the two receiver coils are each connected by an amplifier and rectifier to the same summing amplifier, which supplies a sinusoidal alternating output signal during longitudinal movement of the scale.

According to another preferred embodiment of the invention, each receiver coil has, in parallel, a means of tuning the transmission frequency, in particular, a fixed capacitor, and a means for establishing the symmetry of the reception levels of the two coils, in particular, a variable capacitor.

The attached drawings provide a more detailed understanding of a nonlimiting embodiment of the invention.

Fig. 1 is a lengthwise schematic view of the scale and detector for a device that is consistent with the invention.

Fig. 2 is a partial top view of the detector scale.

Fig. 3, 3b, and 3c represent the signal of the detector shown in Figs. 1 and 2.

Fig. 4 represents the electric schematic of the detector shown in Figs. 1 and 2 and the circuit used to shape the measurement signal.

Fig. 5a and Fig. 5d illustrate signal shapes at various points of the shaping circuit shown in Fig. 4.

Figs. 1 and 2 illustrate a device for the incremental measurement of the displacement and position of two objects relatively movable in translation, whose general characteristics correspond to the teaching of WO-A-89/02570 and WO-A-

91/04456. This device comprises a scale 1 connected to one of two objects and a detector 2 connected to the other object and which explores scale 1.

Scale 1 consists of a metal ribbon, for example, of stainless steel, comprising graduations formed by a succession of longitudinal openings 4 of pitch p. Depending on the length of scale 1, the openings have a width p/2 and are separated by intervals 5 having width p/2, also depending on the length of the scale.

Detector 2 comprises a transmitter part 6, arranged on one side of scale 1, and a receiver part, arranged on the opposite side of scale 1.

The transmitter part 6 comprises, within a common support structure not shown, two transmitter coils 8, each arranged within a coil form 9 consisting, for example, of a ferrite pot core, in such a way that coils 8 are turned toward scale 1. Each circular coil form 9 has a diameter that appreciably corresponds to the width p/2 of openings 4 and intervals 5 between said openings 4 on ribbon 3 constituting scale 1.

Similarly, receiver part 7 can comprise two coils 10 of similar construction as coils 8.

The two transmitter coils 8 and the two receiver coils 10 face each other, these two pairs being offset by a scale length of p + P/2. In this way the movement of the scale always blocks the high-frequency transmission to a receiver whenever the full impact of the HF transmission is received by the other receiver through an opening.

The two transmitting coils 8 are powered by an HF generator 12 in such a way that each transmits a high-frequency field concentrated on the two receivers 10 facing one another. Whenever scale 1 moves as shown by arrow 13, the high-frequency pulsed signal received is amplitude-modulated by the passage of openings 4 and their intervals 5.

Fig. 3a represents the signal induced in the leftmost receiver coil 10 in Figs. 1 and 2 in the presence of an opening 4 between a receiver coil 10 and a corresponding transmitter coil 8. Fig. 3b illustrates the residual signal induced in rightmost receiver coil 10 in Fig. 1, as it passes before interval 5, resulting in a screen between coil 10 and corresponding coil 8. Fig. 3c represents the modulated high-frequency signal induced in each receiver coil 10 during movement of scale 1 as shown by arrow 13.

Signals from the two receiver coils 10 are sent separately to a shaping circuit 14, described in greater detail below, as shown in Fig. 4 and Figs. 5a and 5d.

In Fig. 4 is shown a detector with its two transmitter coils 8 powered in series by high-frequency generator 12 and its two receiver coils 10. Each receiver coil 10 is connected in parallel with a fixed capacitor 15 to tune receiver coil 10 to the transmission frequency, that is, to the frequency of generator 12, and a variable capacitor 16 that can be used to establish symmetry between the reception levels in the two coils 10 nothwithstanding any disparities in the manufacture of the coils, their geometry, mounting, etc. This clearly illustrates

that detection, as explained in the present description, is based on a principle of HF radio transmission and not a ferromagnetic assembly. The modulated high-frequency signal in each receiver coil 10 according to FIG. 3A is transformed in a high-frequency amplifier 17 into an amplitude-modulated alternating signal, as shown in Fig. 5a.

Upon exiting each amplifier 17 the modulated alternating signal is clipped by means of low-threshold diode 18.

Figs. 5b and 5c represent the two modulated high-frequency signals, clipped and shifted 180° from each other, with opposite polarity resulting from inversion of diodes 18.

The two signals according to Figs. 5b and 5c are then sent to summing amplifier 19, which filters the continuous component of these signals and, after summing, can produce a true, symmetric demodulated alternating sinusoidal signal, as shown in Fig. 5d, which can be used as such or, if need be, can be sent to an interpolator to enhance measurement resolution.

Figs. 6, 7, and 8 describe a nonlimiting embodiment of the invention.

Fig. 6 describes a housing 21 containing detectors 7 together with the electronics and guide means 22 for the scale. A cover 24 maintains the two movable slideways in their housings, said slideways being made of an antifriction material and having a longitudinal slot to guide the scale along its edges. The ends of the slot are reinforced against wear from the scale in this region by metal stops 23.

Fig. 7 is a bottom view of cover 24, which shows an integrated retainer 25 which maintains transmitters 6 opposite receivers 7 when cover 24 is attached to housing 21.

FIG. 8 is a cutaway drawing of said cover 24, illustrating transmitters 6 in place and powered in series or in parallel by printed circuit 25. Sealed passages, not shown here, traverse housing 21 and convey power supplied from the high-frequency generator to transmitter circuit 25.